SUMMARIES

1 WORKSHOP SUMMARY

F. PILAT AND W. FISCHER, BNL

Participants from CERN, Cornell, DESY, FNAL, LBNL, and BNL discussed beam based experiments relevant for the LHC and other future hadron colliders. The following areas of activity were identified as the most appropriate for a collaborative effort in the short and medium term:

- Interaction region corrections
- Beam-beam effects
- Collimation
- Luminosity measurement
- Studies with AC dipoles

Teams of people were formed to take part in machine studies at RHIC during summer 2000 and possibly during the fall at the Tevatron. Initial studies are a natural evolution of already planned commissioning activities. We envision that successful studies will evolve into formal beam experiments in the medium term (beyond 2002). Such experiments have to be proposed to and approved by the scientific reviewing boards at BNL and FNAL.

For every team, a coordinator is responsible for proposing a plan for machine studies. It is important that initial studies have a limited scope and support commissioning and operations efforts. Formal machine study proposals will be based on contributions from all team members and agreements from home institutions. The following teams were formed:

Interaction Region Corrections

BNL	F. Pilat, M. Bai, W. Fischer, A. Lehrach, T. Satogata, S. Tepikian
CERN	O. Brüning
FNAL	T. Sen, P. Bagley

The following items are needed to commission and study the RHIC interaction region correction system:

1. Analysis of the instrumentation requirements for the BPM system (turn-by-turn capabilities), kickers (injection and tune meter kickers), tune meter, beam current transformer, beam profile monitor, Schottky system and and AC dipole.
2. A realistic model of RHIC at 65 GeV/u, with the commissioning lattice and field errors measured at 3000 A (the quadrupole current for 65GeV/u is 3131 A)
3. A plan to attack non-linearities one at the time, starting with octupole errors. The correction method should be tested with large known and controlled nonlinearities. Simulated data should be obtained in advance.
4. An automated way to set the interaction region correctors in the control room according to the action-kick minimization correction. Essential is the capability of interfacing the off-line model to the on-line model used in the control room.
5. An operational procedure to optimize the nonlinear corrector settings. Promising observables for tuning are the measured tune spread and line amplitudes in Fourier spectra of turn-by-turn data.

The written proposal will analyze in detail the above listed points. The goal is to have a first draft by March, an agreed upon proposal by June and beam time in July-August 2000.

Beam-beam Effects

BNL	W. Fischer, A. Drees, F. Pilat, V. Ptitsin
CERN	O. Brüning
FNAL	P. Bagley, T. Sen, M. Syphers
LBNL	M. Furman

During the workshop two beam-beam studies emerged as starting points for further investigations: the measurement of beam-beam footprints in the Tevatron and RHIC, and the search for coherent modes in RHIC.

Measured beam-beam tune-shifts give a base-line for future studies. In addition, 'folded' footprints, obtained in Tevatron simulations with large bunch numbers, are a cause for concern since they appear to be correlated with a smaller dynamic aperture.

Simulations indicate that coherent oscillation modes due to beam-beam interactions may be observable in RHIC. It is planned to further investigate this prediction and test it experimentally.

Beam-beam studies are being planned at FNAL for the 36 on 36 bunch operation. The participation of FNAL group members in these efforts should ensure coordination with this collaborative inter-laboratory effort.

Collimation

BNL	A. Drees, N. Catalan-Lasheras, D. Trbojevic
IHEP	V. Biryukov

A novel collimation system, which uses a bent crystal to channel the beam onto a Collimators, is being installed in RHIC. The system may allow precise measurements of transverse diffusion processes. Substantial transverse diffusion is expected from intra-beam scattering during gold operation at storage. The crystal is provided by IHEP, and the collaboration can be naturally extended to beam studies. A written proposal is being prepared.

Luminosity Measurement

BNL A. Drees
LBNL W. Turner

The goal of this collaboration is to establish if the luminosity measurement proposed for the LHC could be tested, at least partially, at RHIC, following the already planned beam test at CERN.

Studies with AC Dipoles

BNL M. Bai, W. Fischer
CERN F. Schmidt

The AC dipole will be possibly installed and commissioned at RHIC in summer 2000. A proposal that details how to use the AC dipole for beam experiments at RHIC will be written and submitted. In addition, the AC dipole in the AGS can be used for tests.

2 SUMMARY OF SINGLE BEAM INVESTIGATIONS SESSION

R. TALMAN, CORNELL

Miscellaneous Comments on Presentations

T. Roser reported on the RHIC test run 1999. In this run the beam diagnostic system performed impressively an lattice measurements are in excellent agreement with model predictions. For 2000 single and colliding beam operation is planned and the gained knowledge would be universal. Specific to RHIC will be the operation with heavy ions for which intra-beam scattering is a dominant effect. This is also of interest to the LHC. Also specific to RHIC is the operation with polarized protons. Gold ions present a good test particle for intra-beam scattering studies and Schottky spectra.

C. Montag showed predicted and observed persistent current effects in the proton ring of HERA. The chromaticity can be predicted to a large degree (within five units) but active on-line correction is still necessary.

W. Fischer presented plans for RHIC machine studies during the year 2000 run. Studies concentrate on establishing an experimental record for many of the basic machine properties. Important study areas are nonlinear detuning and dynamic aperture, intra-beam scattering and persistent current effects. The question arose whether one can study synchro-betatron resonance using a spectral analysis.

F. Pilat discussed plans for compensating interaction region quadrupole field errors in RHIC. There are detailed field measurements and simulations using corrector setting from the the well-established action-angle kick minimization show a significant improvement in the dynamic aperture. For unknown field errors, however, there is no operational compensation algorithm.

D. Trbojevic showed how a bent crystal can be used as a large amplitude diagnostic tool. This may particularly interesting for transverse intra-beam growth rate measurements.

Pros and Cons of Inter-laboratory Collaborations

Collaborations between laboratories have to weigh the advantages and disadvantages of such an approach. Clear advantages are:

- Expertise, algorithms, and codes can be shared
- It is profitable to have small group interaction (e.g. this workshop) and collaborations
- Local advantages, e.g. a modern data acquisition system at RHIC, can establish operational procedures that can be used elsewhere

Disadvantages of inter-lab collaborations are

- A possible loss of focus on local developments
- An exceeding demand for personnel and machine time
- Possible adverse sociological effects (group cohesion)

Past experience, especially with the E778 experiment suggests a number of requirements for a successful collaboration. Among these are

- A strong Institutional support
- A mutual lab interest
- Simple goals
- A minimum of new hardware
- First rate data acquisition systems

Experimental work in a successful collaboration needs to be prepared well in advance. Single particle effects should start with know magnet measurements or expected distributions of magnetic field errors. The study, experiment or correction algorithm should be simulated from these data. The necessary data acquisition systems need to be commissioned as an operational tool. With first experimental results a study or correction algorithm can be refined.

3 SUMMARY OF COLLIDING BEAM INVESTIGATIONS SESSION

M. SYPHERS, FNAL

From now on the Tevatron Collider will collide 36 on 36 bunches and will have two “pacman” bunches per train. In the future, about 100 bunches will be filled in each ring leading to a bunch spacing of 132ns. In this mode a crossing angle is required which is likely to cause the excitation of synchro-betatron resonances. In addition, simulations resulted in “folded” tune footprints which are a reason for concern since they seem to be correlated with a smaller dynamic aperture. RHIC will primarily run in gold operation. It can be used for strong-strong beam-beam investigations.

Issues that need to be studied for the LHC and other future hadron colliders include control over the beam separation with common interaction region triplets, interaction region correction, the “pacman” effect, the dynamic aperture and lifetime as a function of the crossing angle, and

coherent modes. These issues should be addressed in organized studies and experiments.

Detailed plans should include a precise description of the experimental tools needed (strength ranges, resolution, response functions, ...), the measurement procedures (number of data points, required measurement time, transverse or longitudinal kicks, ...), the observables and the analysis procedure.

For this we need a clear and thorough proposal. A core group of individuals at the Tevatron and RHIC should form a collaborative effort. Actual experimental proposals should be presented to the group at the next collaborating meeting for discussion and feedback.

4 SUMMARY OF EXPERIMENTAL TECHNIQUES SESSION

O. BRÜNING, CERN

The LHC and future hadron colliders will be complex machines. Almost 3000 bunches will circulate in the LHC, with different orbits, tunes and other parameters. Furthermore, the LHC can only operate with very small beam losses to avoid quenches of the superconducting magnets. Future hadron colliders therefore require the accurate control of a large number of parameters, and fast and non-destructive measurement techniques.

BPM Based Measurement

Beam position monitors are standard equipment in accelerators. A number of techniques were discussed that use turn-by-turn data from beam position monitors, including local coupling correction, broad-band impedance measurements and the deduction of non-linear accelerator models. For local decoupling procedures, it was pointed out by P. Bagley that

- Global coupling correction is different from local coupling correction
- The minimum tune approach in not a coupling correction at the working point
- The one turn transfer map contains all information on coupling

Y. Papahilippou presented a frequency analysis of turn-by-turn data from which the the broad band impedance can be obtained. In this approach, the real part is determined from the head-tail growth rate and imaginary part from the tune change with time.

F. Schmidt's complex Fourier analysis of turn-by-turn data results in the coefficients of the one-turn map. The technique works best with two beam position monitors 90 degrees apart shows promise for the correction of individual resonances.

New Techniques

W. Turner showed plans to use collision by-products for measuring various parameters with instrumentation inside the LHC TAS and TAN absorbers. Among these are the luminosity L, the relative offset Δx, the crossing angle α and the beam sizes σ_x and σ_Y. Instrumentation inside the absorbers has to be radiation hard equipment to be reliable.

M. Bai reported on the construction for an AC dipole driven with an frequency close to the betatron frequency. Using an adiabatically turn-on the AC dipole can create large coherent oscillations (¿3σ) without emittance increase. Despite its originally purpose as a spin flipper, the device can be used to obtain betatron phases and beta functions and an analysis of the the beam frequencies can reveal the nonlinear characteristics of the machine.

W. Fischer reported on the possibility of transverse echo measurement in RHIC. For this a fast quadrupole is required. Transverse echo measurements would be a novel tool to investigate transverse diffusion mechanisms.